STATE OF OHIO
WATER RESOURCES RESEARCH INSTITUTE

ANNUAL REPORT
Fiscal Year 1964-1965

to

Director Office of Water Resources Research
The United States Department of Interior

Submitted by:

Water Resources Center
The Ohio State University

Sept. 1, 1965

THE OHIO STATE UNIVERSITY
ENGINEERING EXPERIMENT STATION
WATER RESOURCES CENTER
1791 NEIL AVENUE
COLUMBUS, OHIO 43210

293-6108

August 24, 1965

Dr. Roland R. Renne, Director
Office of Water Resources Research
The U.S. Department of Interior
Washington, D.C. 20240

Dear Dr. Renne:

The Water Resources Center at The Ohio State University hereby respectfully submits its Annual Report for Fiscal Year 1965 in accordance with Paragraph 506.2 "Rules and Regulations pursuant to Water Resources Research Act of 1964" - Federal Register Volume 29 No. 235, December 2, 1964.

The period covered by this report is from February 1, 1965 through June 30, 1965. However, comments in the narrative also refer to additional progress on the projects to date. The report covers the four original projects approved, and the results of the Water Resources Symposium held on June 24-25, 1965.

Very truly yours,

George P. Hanna, Jr.

George P. Hanna, Jr.
Director, Water Resources Center

GPH/jm

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INTRODUCTION

The Memorandum of Agreement by and between the Water Resources Center at The Ohio State University and the Director of the Water Resources Research, Department of Interior, for the purpose of conducting water resources research pursuant to the provisions of the Water Resources Research Act of 1964 (PL 88-379), became effective March 9, 1965. The Allotment Agreement for the first year was signed simultaneously and made retroactive to February 1, 1965. The funds provided, ($75,000), under this Allotment Agreement have primarily been used for administration of the Center, for conducting a Water Resources Symposium involving participation of those involved in Ohio water resource problems, and for initiating the several projects that were approved as a part of the Agreement. In the proposal to the Office of Water Research, the Water Resources Center indicated that the current aims and goals would be in conformance with the overall planning associated with the future of Ohio, and that the major goal of the Center would be to further the optimum utilization of water resources consistant with these developments. In order to achieve this goal steps are being taken to develop a "Center of excellence" of research and training, and an associated task force to which the various groups concerned with water resources can look for information and guidance. Efforts are being expended to establish a means of information exchange with various agencies involved in water resources, and to provide a reservoir of well-trained personnel in the various water specialities to fulfill the various needs of industry and public service.

Consistant with these aims and goals, the Advisory Committee of the Water Resources Center, appointed by the President of the University from the several departments and colleges involved in water resources research, elected to initiate the program by concentrating on particular studies involving the available talent, interest, and background of University personnel, as well as available facilities pertinent to water problems of major concern within the state. Consequently the committee selected for study the two areas of immediate concern, acid mine drainage, and the oil field brine wastes. The four projects proposed under this program consist of three involved in the acid mine drainage area and one in the oil field brine wastes pollution problem. A section of this report is further devoted to the description and the current status of each of these projects.

The provisions of the Water Resources Research Act have been particularly helpful in strengthening the development of a continuous research program, cognizant of current needs, and capable of integrating separate but related studies in a comprehensive program directed toward the overall aims and goals. Aware of the special needs for developing a system of communications and exchange of information between the departments within The Ohio State University, as well as all other universities interested in water resources within the State of Ohio, and the State and Federal agencies working on the myriad of problems in the State, the Water Resources Center organized a Symposium on Water Resources Research, held on June 24th and 25th of this year at The Ohio State University, for the purpose of establishing the roles of the various organizations within the framework of water resources research. This symposium was

provided for under the item for Seminars and Conferences in the original proposal for funds and the fiscal information relating to this symposium is included in a later section on fiscal items. The Symposium was attended by 74 participants all of whom are actively involved in water resources planning or studies at the various universities, or with the several Federal and State agencies represented. A copy of the program is included in Appendex 1. Currently the papers presented at this Symposium are being edited for publication in a proceedings which will be ready for distribution early this fall. The symposium was established essentially for the purpose of bringing together the several university and public agency groups involved in water resources research in order to effect a means of communication and coordination of research projects. The program appears to have been very successful and has stimulated consideration of it as an annual event. It is anticipated that the next year's symposium will relate to more specific research problems. Plans are currently being formulated for this symposium.

During the period covered by this report members of the Water Resources Center attended and/or participated in the following regional meetings pertaining to water resources research:

Date	Name	Meeting
3/24/65	C.I. Randles	Second Water Research Symposium, Morgantown, W. Va.
3/28/65	P.R. Dugan	Eighth Conference on Great Lakes Research, University of Michigan, Ann Arbor, Mich.

Date	Name	Meeting
4/8/65	G. P. Hanna, Jr.	Water Resources Research Center Conference, Indiana University, Bloomington, Ind.
4/25/65	C. I. Randles*	American Society of Microbiology, Annual Meeting, Atlantic City, N.J.
5/3/65	G. P. Hanna, Jr.** W. D. Sheets K. S. Shumate*	20th Annual Purdue Industrial Waste Conference, Purdue University
5/20/65	P. R. Dugan C. I. Randles* G. P. Hanna, Jr. E. E. Smith K. S. Shumate	Symposium on Acid Mine Drainage, Mellon Institute, Pittsburg, Pa. (Sponsored by Bureau of Mines)
6/15/65	G. P. Hanna, Jr.	Fourth Rudolfs Research Conference, Rutgers University, New Brunswick, New Jersey
7/6/65	C. A. Dambach	Western Resources Conference, Seminars in Water Resources Research and VCAR Meeting, H. Collins, Colo.
7/7/65	G. P. Hanna, Jr.	Meeting of Regional Data Center Branch, Great Lakes Study Group, Chicago, Ill.
7/26/65	W. D. Sheets K. S. Shumate	National Symposium on Sanitary Engineering Research, Development, and Design, University of Pennsylvania

*Papers presented

ANALYSIS OF LOCAL, STATE, REGIONAL, AND NATIONAL WATER NEEDS PROGRAM OF THE CENTER

The basic problems of the state that are tied in closely to the work of the Center will relate very definitely to the problems of water use and reuse. The entire problem of waste disposal as it relates to water carriage with its associated need for consideration of low flow augmentation and its impact on other competing water uses must be evaluated with respect to possible modifications or even alternative solutions.

More efficient use and reuse of recycled waters for industrial purposes will be a necessary adjunct to the water conservation program. The application of scientific principles and engineering techniques to the overall reduction of organic and inorganic contamination of water resources must be advanced on all fronts.

More insights and research talents in such areas as urban sociology, ecology and demography, resources, geography, economics, community and regional analysis, social organizations and mass communication will be required, and definite research focused on problems of water use and abuse. Mounting population pressures of rural to urban migration and urban to suburban migration multiply these problems of water conservation particularly within our state. Predictable changes in the character of urban populations and economics foreshadow developing problems involving water resources. Economic and social criteria will have to be developed in order to assess optimum values both with respect to individual and multiple use functions. The impounding of waters in suburban areas by metropolitan authorities for use in urban centers generates problems of intercommunity conflicts, regional area planning, mass communication and mass education. These are some of the major problems that have to be dealt with in the ever-growing urban areas in the near future. As our program continues, we anticipate that more effort will be put into this type of study. One of the approved studies for the coming year will involve the economics of the acid mine drainage problem, relating to the analysis of economic means of dealing with acid mine drainage, and the extent to which abatement would be in the economic interests of the region.

The quantity of available water resources requires a characterization of the overall hydrologic cycle to be considered. This will make it necessary to do more studies on small watersheds in order to more definitely characterize the conditions affecting these watersheds. Predictions of the effects of groundwater development, flood control projects, and other factors affecting a change on the overall hydrologic cycle might then be possible. A considerable amount of progress that has already been accomplished in terms of quantative inventory of Ohio water resources by the Ohio Division of Water. It is anticipated that the Water Resources Center will cooperate very closely with the Ohio Division of Water in all of the projects involving hydrologic research. Currently the project involving a study of the groundwater brine pollution in the Morrow County oil fields, is being coordinated very closely with this agency.

PROJECT PROGRESS REPORTS (through June 30, 1965)

WRC-101

DEVELOPMENT OF A "NATURAL" LABORATORY FOR THE STUDY OF ACID MINE DRAINAGE

The professional personnel who have participated in this study include Dr. E.E. Smith and Professor W.D. Sheets of the Department of Chemical Engineering and Dr. K.S. Shumate of the Department of Civil Engineering. In addition, Mr. R.G. Brant, Assistant Chief of the Ohio Division of Geological Survey, has given full cooperation in the detailed planning and execution of the site preparation phase of this study, with particular regard to the geological and hydrological description of the site.

In accordance with the research plan outlined in the Request for Initial Allotment to Establish a Water Resources Research Institute for the State of Ohio, the following progress has been made:

A. Geological, Physical, and Hydrologic Description of the McDaniels Test Mine and Surrounding Area.

Field studies conducted in early April indicated that the primary aquifer supplying the McDaniels Mine with ground water is the massive sandstone formation overlying the coal seam in which the mine is situated. The water flowing into the mine under both flooded and unflooded conditions appears to gain entrance through the sandstone roof. On the other hand, the floor and walls of the mine are relatively impermeable to the flow of water. Therefore, when the outlet valve in the mine seal is closed, the water level in the mine will gradually rise until it reaches an outlet at or near atmospheric pressure, which may be supplied by fractures between the coal and overlying sandstone,

or in the overlying sandstone itself. The route followed by effluent mine drainage under these conditions is indeterminant. For this reason, under conditions of complete flooding of the mine, the only usable indication of influent ground water flow rate will be the hydrostatic head of water in the sandstone surrounding the mine.

In order to further evaluate and describe the test mine and its surrounding area, the work described in the following paragraphs is currently underway:

1. Physical and Geological Description of the Area

   a. Work completed, June 30, 1965

      Prior to May 8, 1965, the mine had been flooded to a depth of approximately three feet above the outlet valve in the mine seal (which was constructed in 1957). On May 8, the valve was opened and the mine drained. Before draining the mine, samples were taken of the atmosphere in the mine above the impounded water, and during the draining operation, samples were taken of the drainage which was concurrently treated with slaked lime to eliminate any possibility of a deterioration of water quality in the stream below the mine. On May 18 the manhole cover in the seal was removed, and the interior of the mine was examined. The mine was found to be structurally sound, and plans were made for an accurate planimetric survey of the mine interior Reference spads were set in the mine roof, and a reference line extended through the seal into the open area in front of the mine. The planimetric survey was finished on June 3, and reference points were placed on the hillside above the mine. The outline of the mine was

traced on the hillside, which allowed the selection of sites for five of six observation wells. The location of the sixth well was determined at the time of the drilling of the wells. A planimetric map of the mine and the prepared observation wells is given in Figure 1.

Having determined the location of the prepared wells, the requisite depths of the wells were estimated, and it was found that the budget would allow the holes to be cored, thereby yielding the maximum possible amount of detailed information on the sub-surface geology of the area surrounding the mine. A detailed bid sheet outlining the specifications for the drilling of the observation wells was made up and submitted to the drillers, each of whom also visited the site of the prepared work. The low bidder was the Columbus Testing Laboratory, Columbus, Ohio. The drilling was completed during the first week in August.

b. Work remaining to be done in preparation of the "Natural" laboratory.

In addition to the planimetric mapping of the mine interior and the sub-surface exploration of the surrounding area by means of the cored observation wells described above, elevation bench marks are being established in the Big Four Hollow, the valley containing the mine. These will serve as reference points for the description of the coal seam in which the McDaniels Mine is situated, as well as for the topographic survey of the mine interior following the removal of the gob from the mine. It is anticipated that this survey work will be completed by the end of August.

In order to have a more clearly defined geological environment within the mine, all of the gob is being removed from the mine interior. This operation is of necessity being done by hand, and is as of this date essentially complete.

Following this operation, samples of coal and associated strata are now being removed from the mine for the recovery of pyritic material for laboratory study, and for the determination of the distribution of pyritic materials within the mine.

2. Hydrological Characterization of the McDaniels Test Mine and Surrounding Area.

As mentioned above, the geological characteristics of the McDaniels Mine area indicate that the predominant aquifer supplying water to the mine is the massive sandstone strata overlying the mine, and forming the roof of the mine itself. Therefore, it is believed that it will be possible to establish a functional relationship between the water levels in the aforementioned observation wells and the rate of influx of ground water into the mine. If the attempt to establish such a function is successful, we will have a means of determining the rate of the inflow of water to the mine even when the mine is flooded to the maximum possible level (several inches below the bottom of the sandstone strata). This application of the observation wells, together with their use as a means of sub-surface exploration, dictated the placement and method of drilling of the wells, as described in (1a) above. Subsequent to the drilling of the wells, the water flowing into the unflooded mine is being channeled out the valve of the mine seal, and flow measurements will be

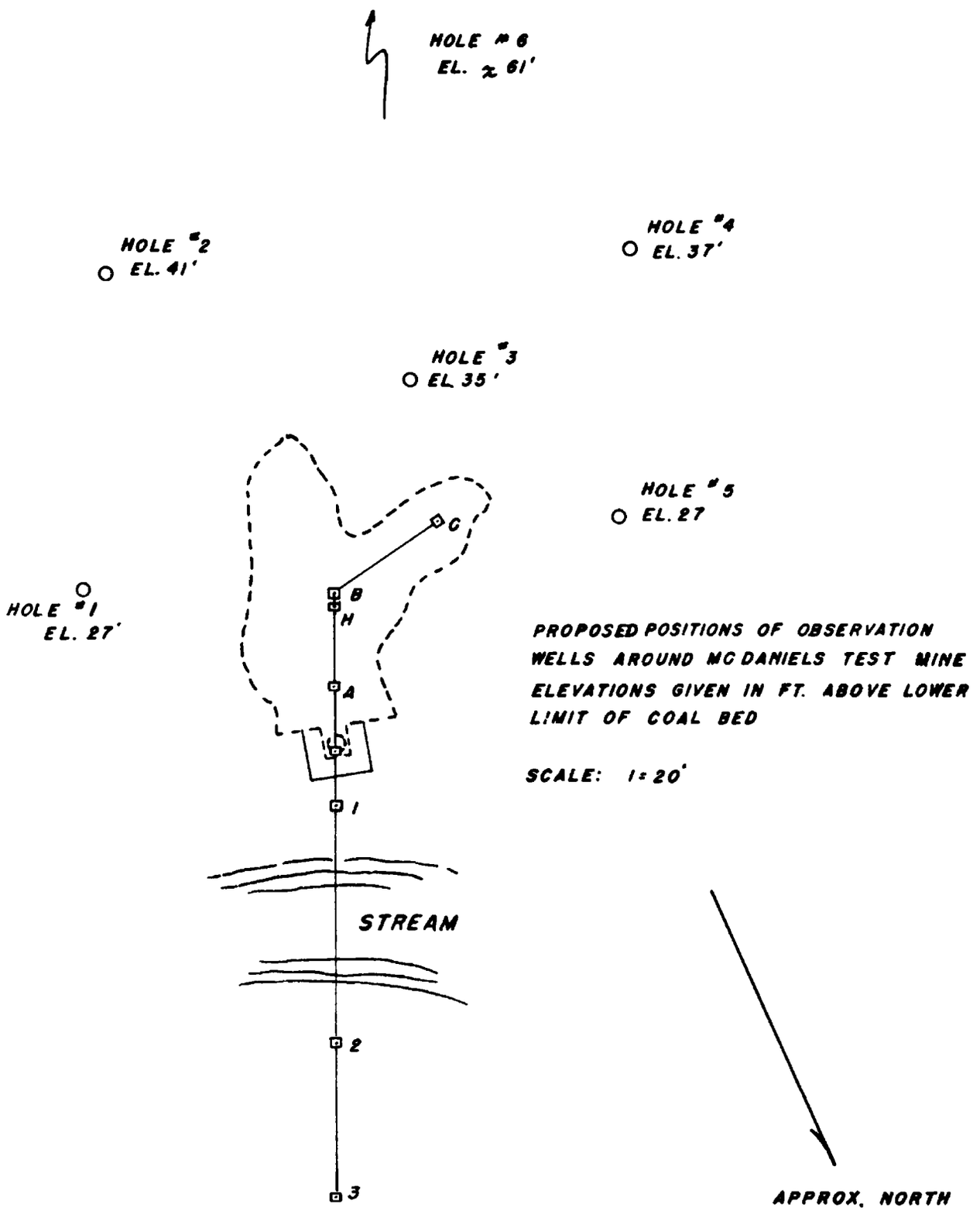
correlated with water levels in the wells, and with ground water temperature. These measurements will continue through the fall and winter. Concurrently, rates of acid produced by the unflooded mine will be determined, to establish a base line of comparison for subsequent alterations of conditions within the mine.

B. Progress in Miscellaneous Details of Site Preparation.

Due to the remote situation of the McDaniels Test Mine from the Water Resources Center laboratory facilities (75 miles), the necessity of taking mine drainage samples throughout the year, and the difficulties involved in preserving samples for significant periods of time prior to analysis, it has become necessary to alter the mine adit to include space for laboratory analysis of samples at the mine site. This sapce will be supplied in an 8' by 8' section of the adit structure which will be included as an integral part of the structure enclosing the access part of the seal. The present frame enclosure is subject to decay due to the continual moisture, and so will be replaced by a cement block structure. The materials for the replacement structure have been ordered, although the mine drainage sampling schedule dictates postponement of the construction until late in September. The seal itself is currently being altered to receive air and water sampling lines extending to selected points and levels within the mine, and still allow access for personnel to move in and out of the mine without requiring dismantling of the sample lines.

To facilitate work during the preparation of the site, and to allow the operation of electrical laboratory equipment later on in the project, the site has been furnished with single phase 220 volt electrical service.

C. To date the project has supported two graduate students and one undergraduate in civil and chemical engineering.



PLANIMETRIC MAP OF MC DANIELS MINE AND OBSERVATION WELLS

FIGURE 1

WRC-102

A STUDY OF THE MICROBIAL FLORA OF ACID WATERS

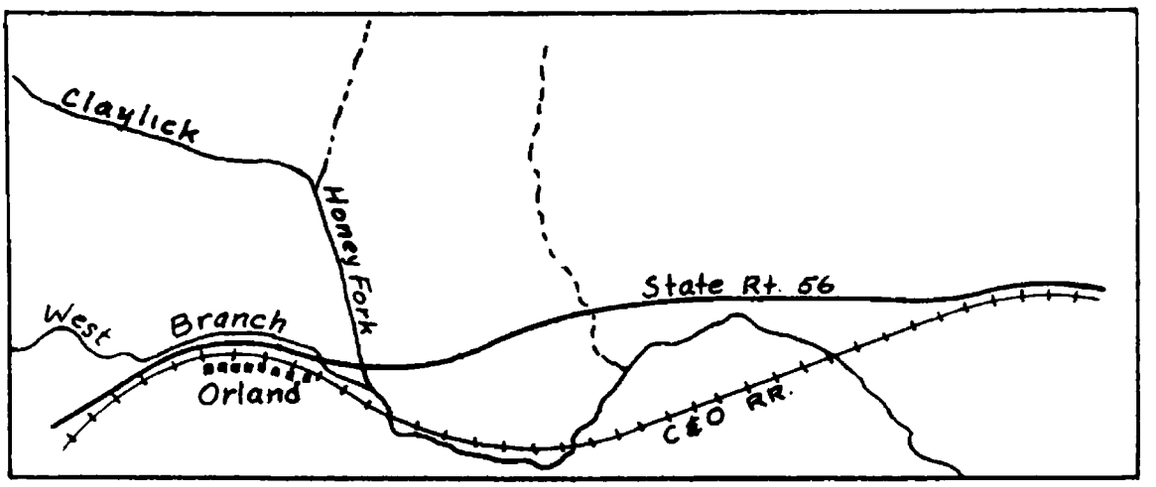
The professional personnel who have participated in this study include Dr. P.R. Dugan and Dr. C.I. Randles, both of the Department of Microbiology.

The first three month period on this project was primarily devoted to organization of the detailed research activity. This included the acquisition and accumulation of essential equipment, supplies and other materials essential for the research. It also included preliminary field examination of the watersheds in Southeast Ohio for the purpose of selecting specific water sampling stations on streams suited to the objectives of this research project.

As proposed, the initial scientific effort will essentially be an ecological study of the microbial flora of acid mine waste polluted streams.

For this purpose, we selected for study the West Branch of Raccoon Creek, a stream which is consistently polluted by acid mine drainage and has a pH generally in the range of 4.5 - 5.5. The reason for selecting this particular stream is that a non-acid polluted (pH 6.5 - 7.0) stream (Honey Fork) merges with West Branch of Raccoon Creek and therefore affords a comparative or control stream under the same geographical and geological and other environmental conditions. We are indicating that Honey Fork is a non-acid polluted stream because of the relatively high pH in comparison to Raccoon Creek and it does approach neutrality. However, the fact that the pH is slightly lower than 7.0 may indicate that a small amount of mine drainage actually enters the stream.

An outline drawing of this study area follows, and shows the Claylick Run stream which is also non-acid polluted.



Sampling Area
New Plymouth Quadrangle
(Scale 1:24,000)

Figure 2

At this time we have isolated about 90 microorganisms in pure culture from the waters described and, as expected, considerably more species are present in Honey Fork than in Raccoon Creek. The 90 organisms include bacteria, yeasts, and other fungi but we have not yet attempted to isolate and classify the algae. Undoubtedly when identification procedures are complete the list of different species will be considerably less than the 90 isolants mentioned.

We have also conducted a cursory survey of the microorganisms in other acid polluted streams in Southeast Ohio. We have concluded that the general microbial types are present in all of the streams samples evaluated and therefore the West Branch of Raccoon Creek can be considered as a typical acid polluted stream. Some differences have been noted in high acid samples taken directly at mine outfalls and we have tentatively divided acid streams into two categories: A) acid = pH above 4.0; and B) high acid = pH below 4.0.

Our investigations then are arbitrarily divided into two separate study systems. A) The acid stream as represented by West Branch of Raccoon Creek and Honey Fork, and B) Highly acid streams which are in close proximity to mine openings and which do not allow comparison to what might be considered water in a "normal" or non-acid condition.

Currently one post-doctoral student, three Ph.D. students, two Masters students, and two undergraduates are working on this project, and are receiving support therefrom.

WRC-103

A BIOLOGICAL SURVEY OF ACID MINE WATERS

The professional personnel who have participated in this study include Dr. C.A. Dambach, and Dr. C.E. Taft of The Ohio State University, and Dr John R. Olive of Ashland College.

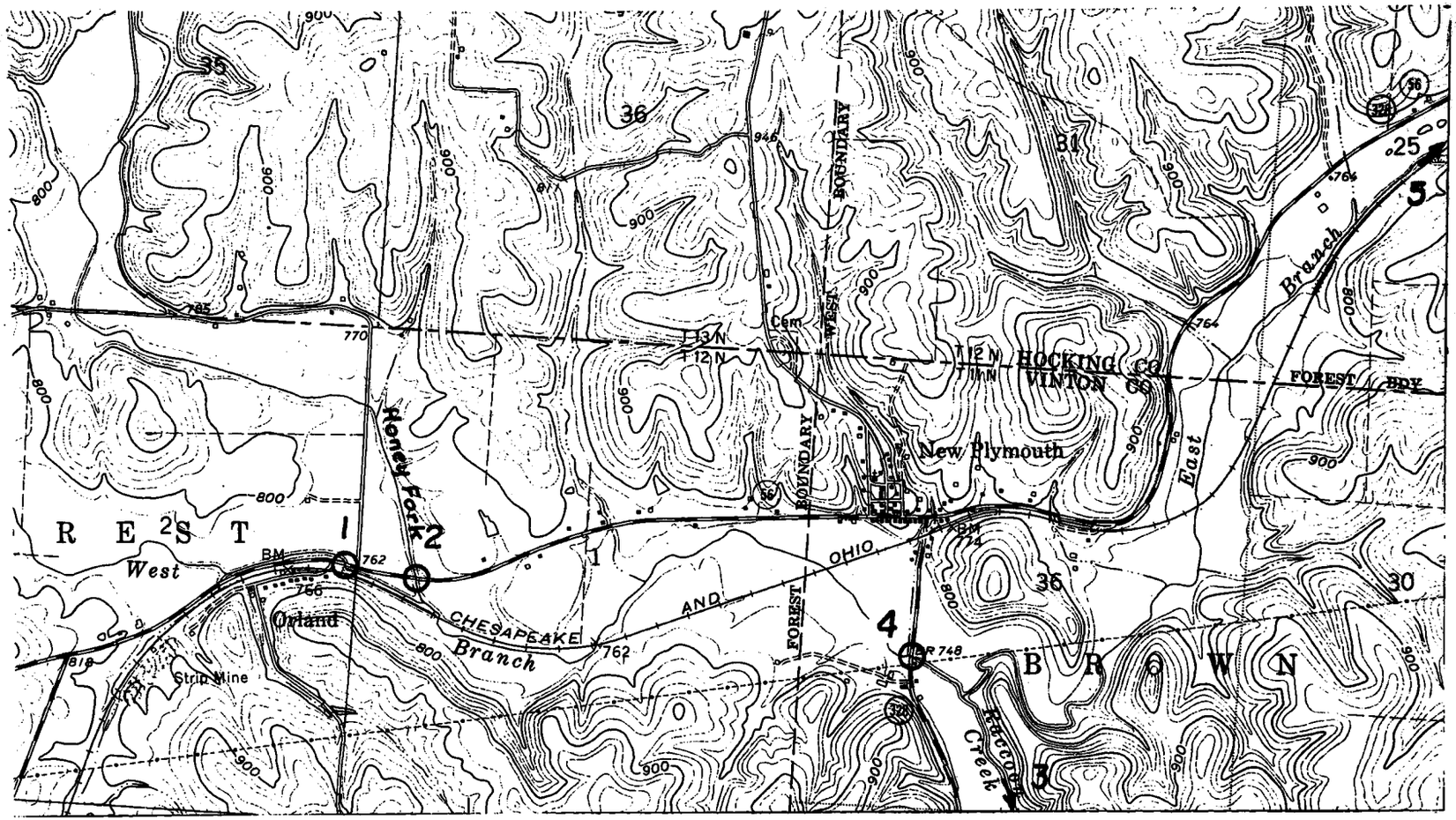
This project was initiated on April 1, 1965 with the employment of Dr. John R. Olive as field supervisor of the project. Dr. Olive immediately proceeded to develop and train field crews for the project and to develop procedures for field work. Equipment for the project was ordered and preliminary field surveys were conducted in the Raccoon Creek, Hocking River, Olentangy River, and Big Walnut Creek watersheds to establish index stations and collecting points. Preliminary collections were made and chemical and biological determinations made at a variety of stations to evaluate procedures and to establish an effective program of collection of samples for biological examination and chemical determination consistent with the range of conditions found and the limits imposed by personnel, funds, and time.

Collecting stations in the Lake Hope and New Plymouth areas where acid mine drainage is a problem were established. These are indicated in the attached maps reproduced from New Plymouth and Mineral quadrangles of U.S.G.S. 7-1/2 minute maps. Chemical determination performed at each station with a Hach portable laboratory are as follows: Phenol Alkalinity, Total Alkalkalinity, Carbon dioxide, Chloride, Hardness -- Ca, Hardness -- Mg, Hardness — total, Iron, Manganese, Nitrate, Oxygen, pH, Phosphate (ortho), Phosphate (meta), Silica, Turbidity, and Temperature.

Collections of biological organisms were made at each station, preserved and taken to the laboratories of the Ohio State University and to Ashland College for purposes of identification and quantitative calculation. Biological sampling included filtering of liter samples through micropore filters for plankton collection, quantitative determination, and identification. A complete listing was made of all algae and protozoans found in grab samples from bottom debris (plants, stems, rock scrapings, etc.), and of the number of bottom organisms present per square meter of bottom sample visible to the unaided eye, and the number of vertebrates present per square meter of area seined with a 1/4" nylon mesh 10' X 4' net.

A similar schedule of work has been developed for the Whetstone Creek area of the Olentangy drainage system. These data are to serve as a check against conditions in the waters affected by acid mine drainage.

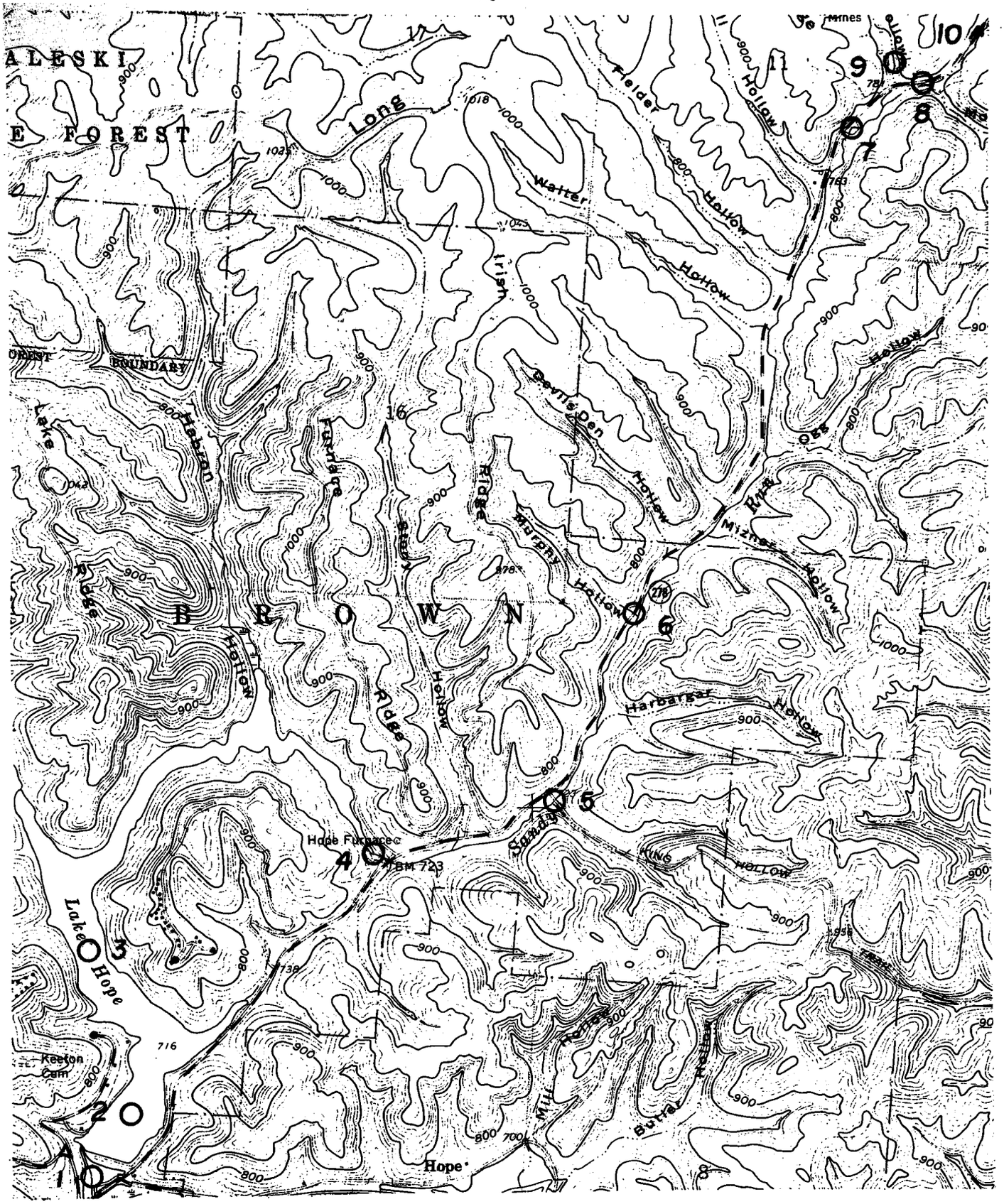
A crew consisting of Mr. Richard Christensen and Mr. John P. Steinback have been employed full-time since mid-June in the Raccoon Creek-Lake Hope area, and Mr. Charles R. Schwartz and Mr. Gary W. Hackett have been employed full-time in the Whetstone Creek area of the Olentangy River drainage. Thus the project currently supports three graduate biologists and one undergraduate engineer.



NEW PLYMOUTH QUADRANGLE

LOCATION OF SAMPLE STATIONS 1 – 5

Figure 3 (Scale 1: 24,000)


ALESKI
E FOREST
FOREST BOUNDARY
Long
Water
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Devils Den
Hollow
Fielder
Hollow
Hollow
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WRC-104

A STUDY OF GROUNDWATER CONTAMINATION DUE TO SALINE WASTE WATER DISPOSAL IN THE MORROW COUNTY OIL FIELDS

Dr. Jay H. Lehr, Department of Geology, is supervising this project.

The purpose of the project is to study the effect of pollution of the ground water in Morrow County, Ohio, due to the introduction of saline oil field wastes through evaporation pits. The investigation is directed toward the determination of the source of pollution, its severity, approximate areal extent, and probable future movements.

The initial approach to the problem was to select three hydrologically different areas and monitor the polluted groundwater as it migrated away from the source. This approach was partially altered when it became apparent that the oil operators were either unable or unwilling to furnish adequate quantitative information about the amount of salt water which had been disposed of through evaporation pits.

An alternative procedure was selected as follows: Evaporation pits in the Olentangy River flood plain, Delaware Township, Ohio are being used as a pilot project which should furnish quantative as well as qualitative data. This location presents the opportunity of studying the direct relationship between a ground water system and a brine water disposal system. The pits drain very fast, indicating a high infiltration rate into the glacial till.

All the parameters in this area can be determined. The size of the reservoir is known, as is the depth to the water table, and therefore the amount of water

in the reservoir. The amount of salt water that has been produced by the oil wells, can, and will, be determined. Consequently this area will lend itself to rather precise quantitative measurements and results.

A regional survey over a portion of Morrow County will compliment the Delaware area study. This regional study will facilitate the mapping of chloride enclaves in the ground water reservoir, produced by a large number of disposal pits. The bedrock surface can be mapped, and the height of the water table will be determined. This will give the amount of water present in the near surface reservoir. By mapping the areal extent of the chloride enclaves, an estimate of the amount of chloride that has been introduced into the ground water can be made. The rate of movement of these enclaves will allow an estimation to be made of the length of time necessary for the reservoir to flush the salt. These investigations are now underway.

Delaware Area: The Delaware area has had saline wastes introduced into the ground water system through two evaporation pits that have been in operation approximately eighteen months. One pit is still being used to dispose of salt water, but the operator of the second pit has abandoned pit disposal and is injecting the water back into the petroleum reservoir through a dry hole drilled near his production.

The Delaware area lies in the flood plain of the Olentangy River. Glacial till, composed primarily of coarse sands and gravels, varies in thickness from 10 to 25 feet. This till is an excellent near surface water source but is somewhat limited in areal extent, being confined to a strip along the river channel approximately one-half mile wide.

A system of fourteen observation wells have been drilled around the pits to define the limits of the chloride enclave. The wells are spaced at varying distances from the pits, allowing calculation of the rate of movement to be made. The wells range in depth from eleven feet to twenty-two feet. Observation wells have been drilled on three sides of the pollution source which are free of excessive chlorides. The Olentangy River borders the fourth side and all wells drilled on the river side of the pits show high chloride contents.

Two series of chemical analyses on water taken from the observation wells have been made to date. These analyses have used the standard Mohr Method Titration for chloride concentration. The chloride concentration in parts per million for the two analyses are as follows:

Analysis #1 July 1, 1965

Well #	Specific Conductance micromhos/cm	Chloride Concentration PPM
1	8000	33,000
2	8000	29,500
3	8000	10,500
4	8000	17,000
5	8000	2,600
6	8000	18,250
7	480	14.5
8	8000	13,000

Analysis #2 July 15, 1965

Well #	Specific Conductance Micromhos/cm	Chloride Concentration PPM
1	8000	34,500
2	8000	35,750
3	8000	13,500
4	8000	19,250
5	8000	3,600
6		25,000
7	1125	16.0
8	8000	8,700
9		
10	750	11.0
11	5200	3,125
12	8000	3,250
13	840	72.0
14	880	14.5

An attempt has been made to correlate specific conductance to chloride concentration but the other ions in the saline water have not permitted a solution to the problem to date.

These wells will continue to be monitored periodically and additional wells drilled as it becomes necessary. Water quality tests will allow a determination of the salt water movement in the system as a result of hydrodynamic flow, mechanical mixing and chemical dispersion.

Regional Survey: A sampling and analysis of water from domestic water wells in a section of Morrow County, Ohio is now underway. An area bounded by two effluent streams (Shaw and Whetstone Creeks) and lying in the heart of the Morrow County oil field was chosen for a regional study of the oil field pollution problem. The aim of the regional study is to map enclaves of chlorides introduced into the ground water body through salt water disposal pits.

The movement of these enclaves will be mapped on a monthly basis by contour isochlor maps based on the results of the sampling program. The ground water movement, and to a limited extent the near surface water resources of the area will be defined by this survey.

The geology of the area presents no great problem. In general there is a layer of glacial till at the surface varying in thickness from approximately 20 feet to as much as 200 feet thick in old buried stream channels. This till is laid down on a glacially eroded shale surface. Most of the domestic wells in the area do not penetrate the shale, therefore, they give an accurate measure of the chlorides that have been introduced through the numerous disposal pits in the area.

Four hundred and twenty-nine domestic water wells have been selected for sampling purposes. Two samples have already been taken from each well and the chloride concentrations determined. From these results, isochlor maps are being made which show the chloride enclaves in the survey area. Attached is a topographic map of the area surveyed, and the initial isochlor of the same area. (pp. 27 and 28)

In most instances the enclaves can be traced to disposal pits that lie within the limits of the chloride build-up. Additional observation wells are being drilled in each area where pollution occurs to substantiate the isochlor interpretation and to better define the limits of pollution. (Note: The normal chloride concentration for the ground water in the area ranges from 10 to 15 parts per million. A figure of 25 parts per million has been taken as the lower limit of pollution for mapping purposes.)

The magnitude of the sampling program makes it a very time consuming operation, therefore an attempt is being made to get individuals to sample their wells each month and leave the sample at a centrally located collection station. The Morrow County Health Department and the Morrow County Extension Agent are cooperating in this effort.

A number of oil operators in the area have discontinued the use of unlined disposal pits in compliance with recently enacted legislation dealing with disposal of saline water by evaporation pits. Others still continue to use pits for disposal purposes, but the amount of ground water pollution by oil field wastes has been curtailed in the last ninety days.

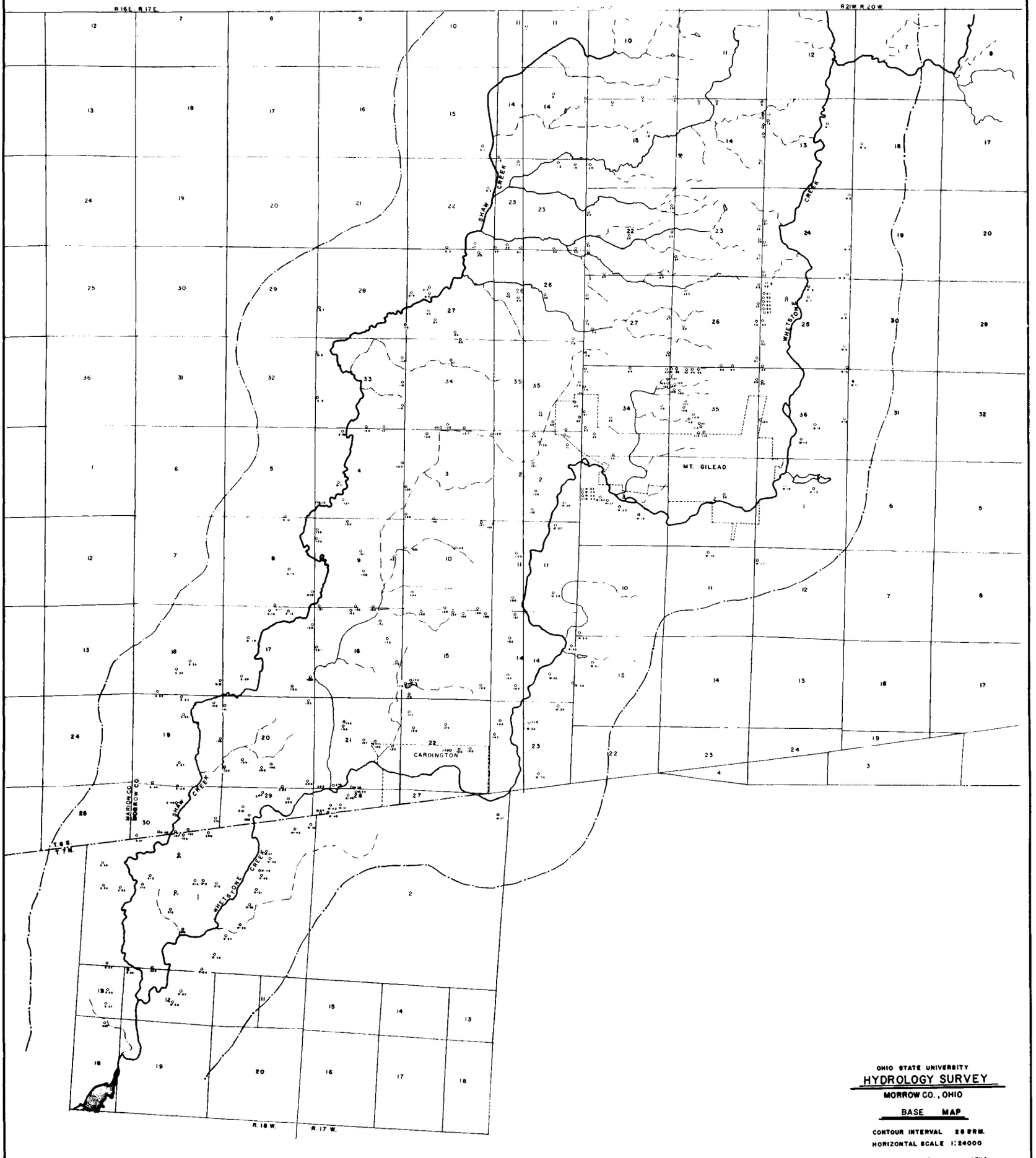
Additional work will include the drilling of additional observation wells to better define the areas of pollution and the drilling of six 4 1/2 inch wells for the installation of continuous water level recording devices. These water level recorders will determine the annual variation of the water table and when correlated with water level readings in the domestic wells will give a very reliable indication of the water table configuration of the area throughout each year.

A continuing program of well sampling, and analysis for chloride concentrations will be maintained throughout the course of the project. Isochlor maps will be made on the basis of these samples and the development and travel of the chloride enclaves will be mapped.

Dispersion of the brine wastes into the ground water will be studied by means of chemical investigations into the ionic exchange between constituent

compounds in the reservoir, and by sorption of the contaminating chemicals by the rock material of the reservoir.

The project currently employs one doctoral candidate, two masters candidates, and one undergraduate, all from the Department of Geology. At least one doctoral thesis is contemplated from this work.



OHIO STATE UNIVERSITY

HYDROLOGY SURVEY

MORROW CO., OHIO

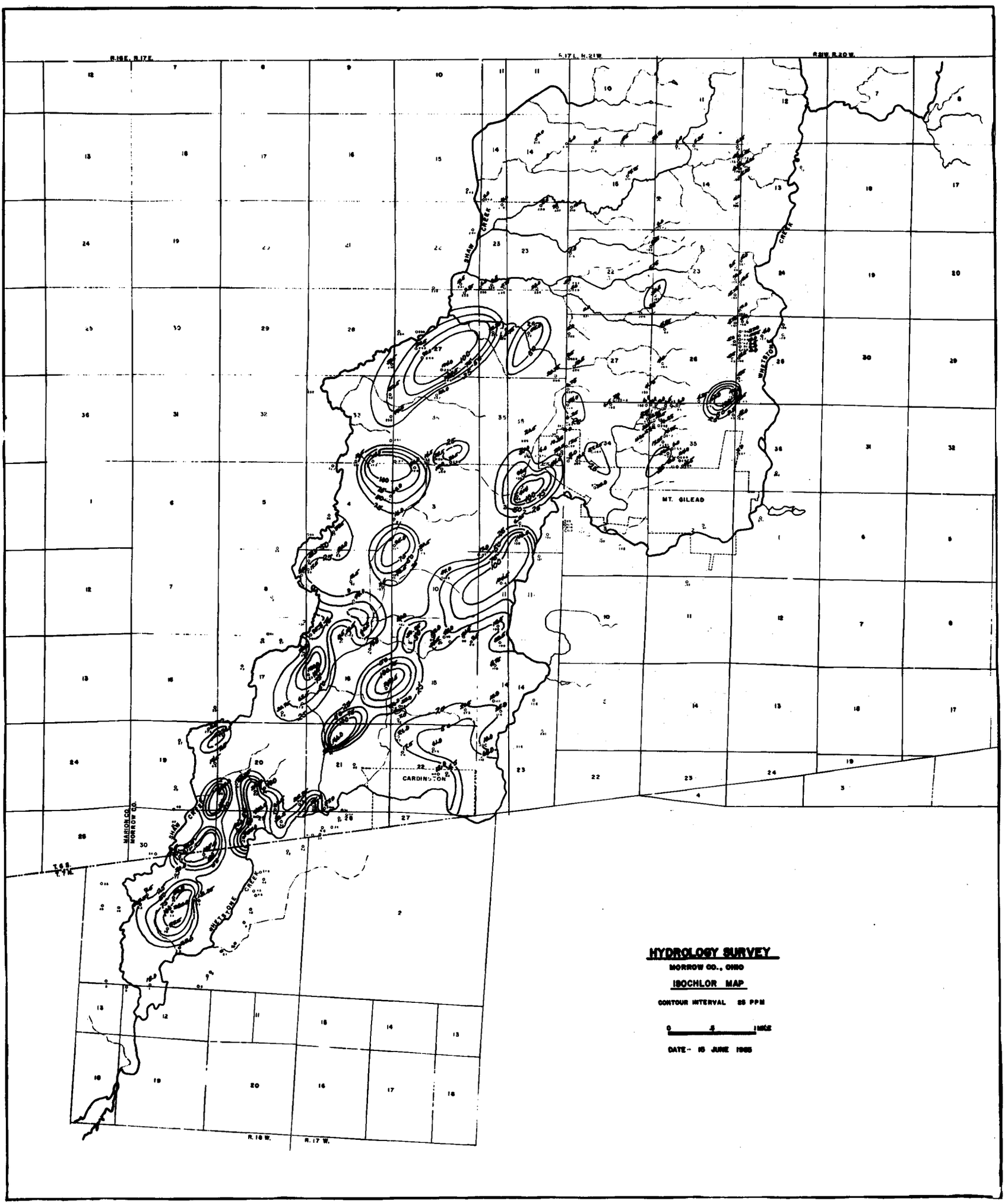
BASE MAP

CONTOUR INTERVAL 20 FEET

HORIZONTAL SCALE 1:24000

0 1 MILE

DATE...


R.15E. R.17E.
T.6S. T.7S.
MARION CO.
MORROW CO.
SHARP CREEK
SWEETDALE CREEK
R. 16 W.
R. 17 W.
T.5 L. N.21W
R.21W. R.20W.
SHARP CREEK
WHETSTONE CREEK
MT. GILEAD
CARDINGTON
HYDROLOGY SURVEY
MORROW CO., OHIO
ISOCHLOR MAP
CONTOUR INTERVAL 25 PPM
0 .5 1 MILE
DATE- 15 JUNE 1965

PROPOSED FY 1966 PROGRAM

The proposed program for fiscal year 1966 was submitted on May 15, and approved under allotment agreement 14-01-0001-805 effective July 1, 1965. This program continues the four projects previously approved and conducted during the current year, and a fifth project WRC-105 "Alternative Economic Responses to the Acid Mine Drainage Problem in Southeastern Ohio". The purpose of the latter research is to analyze the economics of alternative means of dealing with acid mine drainage and the extent to which abatement would be in the economic interests of the region. The study would take account of indirect (secondary and higher order) effects on the economy of the region as a result of adjustments implied for 1) coal mining; 2) economic activities damaged by acid mine drainage; and 3) economic development of the region as a whole under other (Appalachia) programs. The intent would be to discover economically efficient alternatives rather than a unique optimum solution.

The research would pave the way for a wider study of pollution control and water reuse systems in Southeastern Ohio, again, taking account of economic effects on 1) waste dischargers; 2) those damaged; and 3) economic development of the region.

A request for matching fund support of projects as authorized under Section 101, Title I, Water Resources Research Act of 1964 (Public Law 88-379) was submitted on June 14, 1965. The request was made for support of five projects two of which have been approved to date as follows:

"Strontium Isotope Composition and Trace Element Concentration in Lake Huron and Its Principal Tributaries".

This project will involve the measurement of Sr^{87}/Sr^{86} as a reflection of mixing phenomena in the Great Lakes based upon both isotope composition and its concentration. The proposed work constitutes basic research in physical and chemical limnology, and as such, relates to the overall aims and goals of the Water Resources Center, specifically in its approach to the problems of the Great Lakes.

"Strip-Mining and Water Quality".

A study to observe the effects of strip mining in a controlled watershed on the aspects of the watershed's hydrology. This will be a field study extending the results of lysimeter studies in an effort to demonstrate the magnitude of salt production in weathering coal spoils.

Both of these projects are being initiated.

FORM A

ANNUAL REPORT - TRAINING AND EDUCATION ASPECTS OF THE WATER RESOURCES RESEARCH PROGRAM UNDER P.L. 88-379

1(a) New Courses Added Relating to Water Resources

A new course "Measurement Techniques" has been instituted during the last year in Civil Engineering to acquaint the student with sophisticated analytical techniques relating to water quality, such as column and gas chromatography, spectrophotometry, respirometry, etc.

Two new courses in Geology have been developed during the past year with respect to water resources. The first of these "Geology of Water Resources", is a study of the geology and hydrology of surface and subsurface waters with applications to conservation programs. The second of these courses "Hydrogeology", deals with the geologic and hydrologic factors controlling the occurance and behavior of groundwater and surface water. The first course is for undergraduates only. The second course is open to undergraduates in the geology program and to graduate students from other departments.

A special problems course in the Department of Economics relating to water resources analysis has also been started presenting an approach to systems analysis relating to water resources and tying in the problems of water resources with other types of utilities.

A program will be initiated this fall involving a short school presentation of "Basic fundamentals in Groundwater Hydrology". This will be conducted

under the Department of Geology and will be open to graduate engineers and hydrologists who are working in the field. This course is a part of the University's continuing education program.

(b) New Staff Members Added

Dr. Jay H. Lehr joined the Department of Geology in the fall of 1964 to develop a program in hydrogeology and groundwater hydrology. Dr. Lehr is actively participating as project supervisor on the study pertaining to groundwater contamination due to brine field wastes currently being pursued under the allotment.

Dr. Paul E. Taiganides joined the Department of Agricultural Engineering in the winter of 1964, and is currently engaged in water resource activities pertaining to hydrology of small watersheds, as well as to water quality problems. Dr. Taiganides has submitted a proposal for research based on matching funds support and relating to small watershed hydrology which has been forwarded to the Office of Water Resources Research for consideration.

No funds from the allotment were used directly for acquiring new personnel at the University. Research efforts have been directed at the use of current personnel at the University in accordance with Part 502.1 (1) (2) of Rules and Regulations pursuant to the Water Resources Research Act of 1964 requesting avoidance of undue displacement of scientists elsewhere engaged in water resources research.

Indirectly, the existence of the program has sparked the search for both an Engineering Hydrologist and a Resources Economist, both of whom would have teaching positions in their respective departments, but who

would also be expected to enter into the program of the Water Resources Center. It is anticipated that both of these positions will be filled in the near future.

(c) Interdisciplinary Training Capabilities

Provisions were made for interdisciplinary training in Water Resources and related natural resources in The Ohio State University through creation of a Natural Resources Institute on October 1, 1955. The Institute has responsibility "broadly to stimulate and coordinate teaching .. in the conservation, development, and wise use of natural resources" and to "promote the development of suitable major programs of study, both graduate and undergraduate, leading to possible careers in the field of conservation".[1]

The Institute has an interdisciplinary curriculum committee which has developed, in cooperation with interested departments, both undergraduate and graduate training programs. Basically these consist of a core of resource related courses in addition to general University and college requirements.

A special sub-committee on Water Resources training was organized two years ago to develop an interdisciplinary training program in Water Supply and Pollution Control. Eight departments and the Water Resources Center are represented on this sub-committee. A training grant from the Public Health Service provides stipends for six graduate students in this program. The sub-committee selects the trainees on the basis of scholarship potential

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1. From minutes of the Board of Trustees, June 13, 1955.

and the degree of interdisciplinary training shown in their proposed program of study. An interdisciplinary graduate seminar in water resources is part of this program. Registration in this seminar is from eight to sixteen students each quarter.

2. Majors in water related fields in school year ending **September 1965:

	No. Enrolled	No. Graduating
Juniors	15	
Seniors	16	12
Masters degree candidates	14	6
Doctoral degree candidates	7	1
Post-doctoral degree students	1	

**The 1964-65 school year may be considered to have run from the beginning of the fall term in 1964 to the end of the summer term in 1965.

3. Program support of students:

Category of Students	No. Using Equipment, Supplies, etc.	No. Receiving Employment or other Financial Support through Program
Undergraduates	7	7
Masters degree candidates	11	6
Doctoral degree candidates	4	3
Post-doctoral degree students	1	1

4. Employment Status of Majors in Water-Related Fields Who Graduated During the 1964-65 School Year.

Category of Student	Employment Status								
	Unemployed	Advanced Schooling	Water-Related			Non-Water-Related		
			Fed.	State	Other	Fed.	State	Other
Bachelors degree	—	6	1	1	2	—	—	2
Masters degree	—	3	—	1	2	—	—	—
Doctoral degree	—	—	—	—	1(2)	—	—	—

5. Type of Employment of these 1964-65 School Year Graduating Majors

Category of Student	Number of Graduates Engaged In				
	University or Other Teaching	Water Resources Research	Operations & Mgmt.	Planning	Other (Specify)
Bachelors		1	2	2	1(1)
Masters		2	1		
Doctoral					1(2)

(1) Enforcement
(2) Government of Israel

Form B

OFFICE OF WATER RESOURCES RESEARCH

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT - BY SEPARATE PROJECTS

From:	To:
Water Resources Center The Ohio State University 1791 Neil Avenue Columbus, Ohio	Office of Water Resources Research Department of the Interior Washington, D. C. 20240

Date:	Annual report as of:	Fiscal Year 1965 Annual Allotment
September 1, 1965	June 30, 1965	Agreement Number: 14-01-0001-559

Project title (and number if assigned):

PROGRAM ADMINISTRATION - WRC

Fiscal Year 1965 Funds	Amount Budgeted 1/	Actual Expenditures 2/
A. Salaries and Wages - Total	$ 5,901	$ 6,319
1. Principal investigator(s) and other professional staff	(3,959)	(4,822)
2. Graduate student assistants	( )	( )
3. Others	(1,942)	(1,497)
B. Non-expendable Property 3/	2,000	1,449
C. Expendable Supplies and Materials		451
D. Other (specify) such as Travel - Total	2,850	2,525
1. Travel	(1,000)	(1,014)
2. Maintenance (repair, replacement and service communications)	(1,850)	(1,511)
3.	( )	( )
Totals: 4/	$ 10,751	$ 10,744

Submitted by:

Name: George P. Hanna, Jr. Title: Director, Water Resources Center

1/ As set forth in project budgets (and revisions) submitted to and accepted by the Office of Water Resources Research.

2/ Firm outstanding commitments should be considered as expenditures for purpose of this report.

3/ Non-expendable property is defined as property which has continuing use as a self contained unit; is not consumed in use; does not ordinarily become a fixture or loose its identity, or form a component of equipment, machine, plant, etc.

4/ For purpose of this report, if project expenditures (total of all cost categories) vary up or down more than 10% from the budget estimate of total project expenditures, an explanation of such variance should be provided on an attachment to this report.

Form B

OFFICE OF WATER RESOURCES RESEARCH

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT - BY SEPARATE PROJECTS

From:	To:
Water Resources Center The Ohio State University 1791 Neil Avenue Columbus, Ohio	Office of Water Resources Research Department of the Interior Washington, D. C. 20240

Date:	Annual report as of:	Fiscal Year 1965 Annual Allotment
September 1, 1965	June 30, 1965	Agreement Number: 14-01-0001- 559

Project title (and number if assigned):

Fiscal Year 1965 Funds	Amount Budgeted 1/	Actual Expenditures 2/
A. Salaries and Wages - Total		$ 664
1. Principal investigator(s) and other professional staff	( )	( )
2. Graduate student assistants	( )	( )
3. Others	( )	(664)
B. Non-expendable Property 3/		
C. Expendable Supplies and Materials		777
D. Other (specify) such as Travel - Total	$ 2,300	900
1.	( )	( )
2.	( )	( )
3. Symposium (total budgeted)	(2,300)	(900*)
Totals: 4/	$ 2,300	$ 2,341

Submitted by:

Name: George P. Hanna, Jr. Title: Director, Water Resources Center

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*Total $900 includes $500 for honoraria and
$400 for Symposium Proceedings

Form B

OFFICE OF WATER RESOURCES RESEARCH

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT - BY SEPARATE PROJECTS

From:	To:
Water Resources Center The Ohio State University 1791 Neil Avenue Columbus, Ohio	Office of Water Resources Research Department of the Interior Washington, D. C. 20240

Date:	Annual report as of:	Fiscal Year 1965 Annual Allotment
September 1, 1965	June 30, 1965	Agreement Number: 14-01-0001-559

Project title (and number if assigned):
DEVELOPMENT OF A 'NATURAL LABORATORY' FOR THE STUDY OF ACID MINE DRAINAGE - WRC-101

Fiscal Year 1965 Funds	Amount Budgeted 1/	Actual Expenditures 2/
A. Salaries and Wages - Total	$ 7,330	$ 7,304
1. Principal investigator(s) and other professional staff	(3,566)	(5,181)
2. Graduate student assistants	(3,764)	(2,123)
3. Others	( )	( )
B. Non-expendable Property 3/		33
C. Expendable Supplies and Materials	390	423
D. Other (specify) such as Travel - Total	6,540	5,152
1. Travel	(1,140)	(1,150)
2. Site clearing, borings, construction, etc.	(5,400)	(4,002)
3.	( )	( )
Totals: 4/	$ 14,260	$ 12,912

Submitted by:

Name: George P. Hanna, Jr. Title: Director, Water Resources Center

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Form B OFFICE OF WATER RESOURCES RESEARCH

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT - BY SEPARATE PROJECTS

From:	To:
Water Resources Center The Ohio State University 1791 Neil Avenue Columbus, Ohio	Office of Water Resources Research Department of the Interior Washington, D. C. 20240

Date:	Annual report as of:	Fiscal Year 1965 Annual Allotment
September 1, 1965	June 30, 1965	Agreement Number: 14-01-0001-559

Project title (and number if assigned):

A STUDY OF THE MICROBIAL FLORA OF ACID WATERS - WRC-102

Fiscal Year 1965 Funds	Amount Budgeted 1/	Actual Expenditures 2/
A. Salaries and Wages - Total	$ 14,245	$ 14,556
1. Principal investigator(s) and other professional staff	(7,770)	(7,893)
2. Graduate student assistants	(6,475)	(6,663)
3. Others	( )	( )
B. Non-expendable Property 3/	4,500	5,222
C. Expendable Supplies and Materials	1,500	462
D. Other (specify) such as Travel - Total	900	651
1. Travel	(700)	(651)
2. Reports	(200)	( )
3.	( )	( )
Totals: 4/	$ 21,145	$ 20,891

Submitted by:

Name: George P. Hanna, Jr. Title: Director, Water Resources Center

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Form B

OFFICE OF WATER RESOURCES RESEARCH

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT - BY SEPARATE PROJECTS

From:	To:
Water Resources Center The Ohio State University 1791 Neil Avenue Columbus, Ohio	Office of Water Resources Research Department of the Interior Washington, D. C. 20240

Date:	Annual report as of:	Fiscal Year 1965 Annual Allotment
September 1, 1965	June 30, 1965	Agreement Number: 14-01-0001- 559

Project title (and number if assigned):

A BIOLOGICAL SURVEY OF ACID MINE WATERS - WRC-103

Fiscal Year 1965 Funds	Amount Budgeted 1/	Actual Expenditures 2/
A. Salaries and Wages - Total	$ 7,270	$ 7,303
1. Principal investigator(s) and other professional staff	(3,200)	(3,210)
2. Graduate student assistants	(4,070)	(4,093)
3. Others	( )	( )
B. Non-expendable Property 3/	3,232	1,786
C. Expendable Supplies and Materials		1,411
D. Other (specify) such as Travel - Total	2,040	2,207
1. Travel	(2,040)	(2,207)
2.	( )	( )
3.	( )	( )
Totals: 4/	$ 12,542	$ 12,707

Submitted by:

Name: George P. Hanna, Jr. Title: Director, Water Resources Center

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4/ For purpose of this report, if project expenditures (total of all cost categories) vary up or down more than 10% from the budget estimate of total project expenditures, an explanation of such variance should be provided on an attachment to this report.

Form B

OFFICE OF WATER RESOURCES RESEARCH

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT - BY SEPARATE PROJECTS

From:	To:
Water Resources Center The Ohio State University 1791 Neil Avenue Columbus, Ohio	Office of Water Resources Research Department of the Interior Washington, D. C. 20240

Date:	Annual report as of:	Fiscal Year 1965 Annual Allotment
September 1, 1965	June 30, 1965	Agreement Number: 14-01-0001-559

Project title (and number if assigned):
A STUDY OF GROUND WATER CONTAMINATION DUE TO SALINE WASTE WATER DISPOSAL IN THE MORROW COUNTY OIL FIELDS - WRC-104

Fiscal Year 1965 Funds	Amount Budgeted 1/	Actual Expenditures 2/
A. Salaries and Wages - Total	$ 3,342	$ 3,391
1. Principal investigator(s) and other professional staff	( )	( )
2. Graduate student assistants	(3,342)	(3,391)
3. Others	( )	( )
B. Non-expendable Property 3/	3,860	3,538
C. Expendable Supplies and Materials		437
D. Other (specify) such as Travel - Total	6,800	6,908
1. Travel	(2,740)	(2,809)
2. Observation wells, services, etc.	(4,060)	(4,099)
3.	( )	( )
Totals: 4/	$ 14,002	$ 14,274

Submitted by:

Name: George P. Hanna, Jr. Title: Director, Water Resources Center

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3/ Non-expendable property is defined as property which has continuing use as a self contained unit; is not consumed in use; does not ordinarily become a fixture or loose its identity, or form a component of equipment, machine, plant, etc.

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Form C

OFFICE OF WATER RESOURCES RESEARCH

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT - PROGRAM SUMMARY

From:	To:
Water Resources Center The Ohio State University 1791 Neil Avenue Columbus, Ohio	Office of Water Resources Research Department of the Interior Washington, D. C. 20240

Date:	Annual Report as of:	Fiscal Year 1965 Annual Allotment
September 1, 1965	June 30, 1965	Agreement Number: 14-01-0001-559

Fiscal Year 1965 Funds	Amount Budgeted 1/	Actual Expenditures 2/
A. Salaries and Wages - Total 4/	$ 38,088	$ 39,537
1. Principal investigator(s) and other professional staff	(18,495)	(21,106)
2. Graduate student assistants	(17,651)	(16,270)
3. Others	(1,942)	(2,161)
B. Non-expendable Property 3/ 4/	13,592	12,028
C. Expendable Supplies and Materials 4/	1,890	3,961
D. Other (specify), such as Travel - Total 4/	21,430	18,343
1. Travel	(7,620)	(7,831)
2. Repairs, communications, maintenance, construction	(11,510)	(9,612)
3. Symposium	(2,300)	(900*)
Totals:	$ 75,000	$ 73,869

Submitted by:

Name: George P. Hanna, Jr. Title: Director, Water Resources Center

1/ As set forth in annual allotment program budget (and revisions) submitted to and accepted by the Office of Water Resources Research.

2/ Firm outstanding commitments should be considered as expenditures for purpose of this report.

3/ Non-expendable property is defined as property which has continuing use as a self-contained unit; is not consumed in use; does not ordinarily become a fixture or loose its identity, or form a component of equipment, machine, plant, etc.

4/ For purpose of this report, if total annual allotment expenditures for this cost category (i.e., total for this cost category for all projects, and program administration, included in program) vary up or down more than 10% from the budget estimate, an explanation of such variance should be provided on an attachment to this report.

*Honoraria and Symposium Proceedings

*Other costs of Symposium are included in separable items (See Form B pp. 37)

FORM C (Supplement)

FISCAL YEAR 1965 - ANNUAL ALLOTMENT FISCAL REPORT ESTIMATE OF NON-FEDERAL CONTRIBUTION TO PROGRAM

Estimate of Non-Federal contribution (funds for salaries, etc., and estimated value of "in kind" contributions of laboratory space, equipment, etc.) used in conjunction with the Federal Section 100 Allotment program from period of April 1, through June 30, 1965:

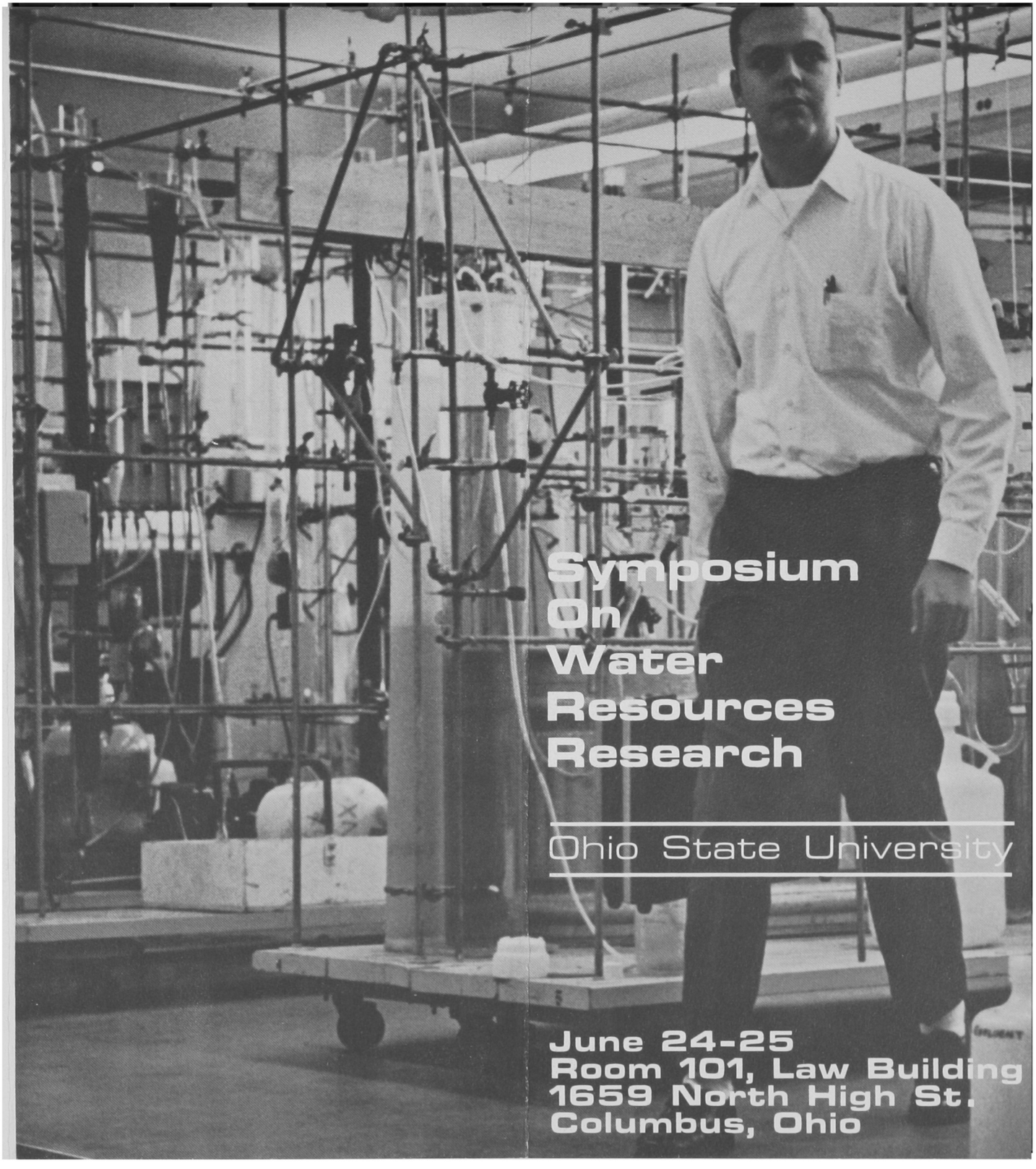
1. Professional and staff salaries contributed by the University	$ 1,575
2. Retirement contributions by the University for all salaried personnel	1,092
3. The following estimated contributions are based on negotiated overhead rates established with Federal Agencies:	
Administration and general (accounting services, pruchasing services, etc.)	4,003
Workmen's Compensation	304
Operation and maintenance	3,715
Library	528
Use allowance-buildings	1,505
Use allowance-equipment	1,296
Indirect expenses(heat, light, other utilities, etc.)	4,659
Total estimated non-Federal contributions	$18,677

Cover photograph: A laboratory of the Water Resources Center, Ohio State University.

This two-day symposium on water resources research is sponsored by the Water Resources Center of Ohio State University.

Symposium On Water Resources Research

June 24-25
Room 101, Law Building
1659 North High St.
Columbus, Ohio



Thursday, June 24

Room 101 Law Building

Morning Session

Dr. A. B. Garrett, Vice President for Research, The Ohio State University, **Presiding**

9:15 **Welcome by Dr. Garrett**

9:30 ***A New Role for Universities in Water Resources Research***

Dr. Roland R. Renne, Director, Office of Water Resources Research, U. S. Department of Interior, Washington, D. C.

10:15 ***How We Have Organized to Meet the Challenge***

Mr. George P. Hanna, Jr., Director, Water Resources Center, The Ohio State University

10:45
11:00 **Recess**

11:00 -
12:15 ***The Interest of the Ohio Department of Natural Resources in Water Resources Research***

Mr. Fred E. Morr, Director, Ohio Department of Natural Resources and **Mr. C. Vernon Youngquist,** Chief, Division of Water, Ohio Department of Natural Resources

12:30 **Lunch,** Franklin Room, Ohio Union

Dr. Arthur D. Lynn, Jr., Associate Dean, College of Commerce, **Presiding**

The Role of "Resources for the Future" in Water Resources Research and Development

Mr. Irving K. Fox, Vice President, Resources for the Future, Washington, D. C.

Afternoon Session

Dr. Patrick R. Dugan, Assistant Professor, Department of Microbiology, **Presiding**

1:30 ***Water Resources Research Needs as Seen by State Public Health Agencies***

Mr. George D. Eagle, Chief, Division of Sanitary Engineering, Ohio Department of Health

2:00 ***Water Resources Research Needs as Seen by the U. S. Public Health Service***

Mr. H. W. Poston, Regional Program Director, Great Lakes Pollution Survey, U. S. Public Health Service, Chicago, Ill.

3:00 **Comment and Discussion**

Martin D. Keller, M.D., Associate Professor, Department of Preventive Medicine

3:30 **Recess**

3:45 ***Water Resources Problems and Research Programs of the Central States Forest Experiment Station***

Mr. Ronald Z. Whipkey, Research Forester and Project Leader, Central States Forest Experiment Station, Forest Service, U. S. Department of Agriculture

Comment and Discussion

Dr. George S. Taylor, Professor, Department of Agronomy

4:30 **Adjourn**

6:30 **Dinner,** Franklin Room, Ohio Union

Mr. Robert J. Tait, Acting Executive Director, Engineering Experiment Station, **Presiding**

Water Resources Research Needs as They Are Seen by Industry

Mr. John E. Lockhart, Manager, Plant Facilities and Maintenance, General Electric Company, Cincinnati, Ohio, and Commerce and Industry Representative on the Ohio Water Commission.

Friday, June 25, 1965
Room 101 Law Building

Morning Session

Dr. Christen T. Jonassen, Professor, Department of Sociology and Anthropology, **Presiding**

9:15 ***Water Resource Research Problems and Programs of the U. S. Geological Survey***

Dr. Joseph E. Upson, Assistant Chief, Branch of General Hydrology, U. S. Geological Survey, Washington, D. C.

9:45 **Comment and Discussion**

Dr. Jay H. Lehr, Assistant Professor, Department of Geology

10:00 ***Water Resources Problems and Research Needs in the Great Lakes***

Colonel Leonard Goodsell, Executive Secretary, The Great Lakes Commission, Ann Arbor, Michigan

10:30 **Comment and Discussion**

Dr. Richard A. Tybout, Professor, Department of Economics

10:45 **Recess**

11:00 ***Water Resources Problems and Research Needs in Agriculture***

Mr. Lloyd L. Harrold, Chief, Soil and Water Conservation Research Station, Agricultural Research Service, U. S. Department of Agriculture, Coshocton, Ohio

11:45 **Comment and Discussion**

Mr. Arnold S. Kleinhenz, State Conservation Engineer, Soil Conservation Service, U. S. Department of Agriculture, Columbus, Ohio

12:30 **Luncheon,** South Terrace Room, Ohio Union

Dr. Robert C. Stephenson, Executive Director, The Ohio State University Research Foundation, **Presiding**

Water Resources Research Needs as Seen by Battelle Memorial Institute

Mr. Richard J. Anderson, Assistant to the Vice President, Battelle Memorial Institute, Columbus, Ohio

Afternoon Session

Mr. W. Raymond Mills, Assistant Professor, City and Regional Planning, The Ohio State University, **Presiding**

1:30 ***Water Resource Problems and Research Needs of the Corps of Engineers, U. S. Department of Defense***

General W. B. Leber, Division Engineer, Ohio River Division, Corps of Engineers, U. S. Department of Defense, Cincinnati, Ohio

2:15 ***Water Resource Problems and Research Needs of Watershed Conservancy Districts***

Mr. Max L. Mitchell, Chief Engineer, Miami Conservancy District, Dayton, Ohio

3:00 **Comment and Conference Summary**

Dr. Charles A. Dambach, Director, Natural Resources Institute, The Ohio State University